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RUNNING MILEAGE, MOVEMENT MILEAGE, AND FITNESS IN MALE U.S. NAVY RECRUITS

*T. V. Trank
D. H. Ryman
R. Y. Minagawa
D. W. Trone
R. A. Shaffer*

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**NAVAL HEALTH RESEARCH CENTER
P O BOX 85122
SAN DIEGO, CA 92186-5122**

**BUREAU OF MEDICINE AND SURGERY (MED-02)
2300 E ST. NW
WASHINGTON, DC 20372-5300**



Running mileage, movement mileage, and fitness in male U.S. Navy recruits

TAMARA V. TRANK, DAVID H. RYMAN, RAHN Y. MINAGAWA, DANIEL W. TRONE, and RICHARD A. SHAFFER

Naval Health Research Center, Division of Clinical Epidemiology, Department of Health Sciences and Epidemiology, San Diego, CA

ABSTRACT

TRANK, T. V., D. H. RYMAN, R. Y. MINAGAWA, D. W. TRONE, and R. A. SHAFFER. Running mileage, movement mileage, and fitness in male U.S. Navy recruits. *Med. Sci. Sports Exerc.*, Vol. 33, No. 6, 2001, pp. 1033–1038. **Purpose:** The purpose of this study was to determine whether there is a relationship between overall fitness improvement and varying amounts of running and movement mileage. **Methods:** Subjects were male U.S. Navy recruits ($N = 1703$, 25 divisions), ages 17–35 yr (mean age = 20.1 ± 2.9 yr), who attended boot camp from April 1996 through August 1996. During the first week of training, recruits performed a 1.5-mile run to determine baseline fitness levels. The results from the initial run were compared with a final 1.5-mile run conducted 6 wk later. **Results:** Based on an age-adjusted fitness scale for a 1.5-mile run time, about one third of the recruits began recruit training in “Excellent-Superior” condition ($N = 558$), one third began in “Good” condition ($N = 582$), and one third began in “Poor-Fair” condition ($N = 563$). Running mileage among divisions ranged from 11.5 to 43.5 miles for the entire 7-wk training period (mean = 22.7 ± 7.2 miles; 8–22 run days, mean = 13 ± 4 d). In addition to running, the divisions accumulated many movement miles (110–202 miles; mean = 145 ± 26 miles) while marching in formation. Recruits who began training in Poor-Fair condition improved the most with an average decrease in run time of $1:55 \pm 1:06$ min (15.6% improvement). The Good group improved by 47 ± 37 s (7.3% improvement), and the Excellent-Superior group improved by 17 ± 32 s (2.9% improvement). **Conclusion:** The magnitude of fitness improvement, as measured by run time improvement, was directly related to baseline fitness level but not related to movement mileage or high-intensity run mileage accrued during training. **Key Words:** FITNESS IMPROVEMENT, RUN MILEAGE, MOVEMENT MILEAGE

Nieman (21) defined cardiorespiratory fitness as “the ability to continue or persist in strenuous tasks involving large muscle groups for extended periods of time.” By attaining aerobic fitness, the circulatory and respiratory systems are able to adjust quickly to and recover from moderate-to-vigorous activities, such as running, swimming, cycling, and brisk walking. Cardiorespiratory fitness also offers protection from a myriad of health disorders, including cardiovascular disease, stroke, hypertension, diabetes mellitus, and obesity (6,22,29). To achieve cardiorespiratory fitness, the American College of Sports Medicine currently recommends the following training guidelines: a) frequency: 3–5 d·wk⁻¹; b) intensity: 55–90% of maximal heart rate, or 40–85% of maximum oxygen uptake or heart rate reserve; and c) duration: 20–60 min of continuous or intermittent aerobic activity, i.e., 8- to 10-min bouts accumulated throughout the day (25).

Self-report surveys show that only 22% of American adults adhere to the exercise levels recommended for health benefits, and at least 24% of adults ages 18–34 yr claim to be completely sedentary (23). A subset of this young adult population, 180,000 in 1998, enters military service annu-

ally with similar poor exercise habits (17). These new recruits immediately engage in a rigorous fitness program that may include excessive running mileage early in the training process. As a result of their relatively poor baseline fitness levels and the sudden increase in vigorous physical activity at boot camp, these recruits are prone to training-related musculoskeletal injuries that result in lost training time, increased training costs, and decreased operational readiness (3).

In addition to planned physical training sessions, recruits typically march at an intensity equal to or greater than a brisk walk (3–4 mph) intermittently throughout the course of each training day. These bouts of marching movement add up to an average of 20–25 miles·wk⁻¹. The cumulative benefits of intermittent physical activity (moderate or higher) performed throughout the day are just being elucidated (2,10,12,13,15,27). Health benefits from exercise begin with any increase over resting expenditure and peak at a net weekly expenditure of 1500 kcal (28). A conservative calculation of weekly energy expenditure from marching alone accounts for 1800–2500 kcal for a 60-kg recruit (1). Thus, recruits should experience a training effect from the accumulated marching and incidental activity, termed movement mileage, independent of the running mileage completed during boot camp. Additionally, the improvement in physical fitness over the course of boot camp should follow a dose-response curve (15,23). Because the least-fit recruits would have the most to gain by an increase in

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physical activity level, they would experience the greatest fitness improvement in their cohort. In a sedentary individual, $\dot{V}O_{2\max}$ may increase by as much as 25% in the first 4–6 wk of moderate-intensity training, such as walking 3–4 mph daily for 30 min (18).

The purpose of this study was to determine whether there is a relationship between overall fitness improvement and varying amounts of running and movement mileage. In addition, this study analyzed the relationship between fitness improvement and baseline fitness levels.

METHODS

Subjects

Male Navy recruits ($N = 1703$) attending boot camp at the Recruit Training Command (RTC) in Great Lakes, IL, between April 30 and August 7, 1996, participated in this study. The population age ranged from 17 to 35 yr (mean age = 20.1 ± 2.9 yr). As subjects arrived at RTC, they were assigned to 25 different recruit training divisions, each consisting of 60–85 men. Initially, 1979 recruits were scheduled to participate in this study; however, 276 of these recruits (13.9% of the enrollees) were eliminated from the study for a number of reasons. Most commonly, these recruits were set back in training due to medical reasons or a failure to achieve academic standards. Others had conflicting schedules that prevented them from participating in one or both of the run tests. Human subjects participated in this study giving their free and written informed consent. This research has been conducted in compliance with all applicable Federal Regulations governing the Protection of Human Subjects in Research.

Study Design

This study compared the fitness improvement among subjects undergoing varying levels of running and movement mileage using initial and final fitness testing. U.S. Navy recruit training consisted of 8 wk of standardized military instruction, which included general physical conditioning (flexibility, aerobic activity, and calisthenics), close-order drill/marching, and classroom instruction on various Navy topics. Recruits completed a timed, maximal effort 1.5-mile run during the first week of training. Recruit Division Commanders (RDCs) instructed the recruits to complete the distance in the shortest time possible. The recruits treated the event as a competition and were self-motivated to do their best. In addition, recruits received verbal encouragement from the RDCs and fellow recruits. Throughout training, RDCs for each Division monitored daily movements and exercise in log books. These logs indicated that all Divisions stretched before and after exercise during a 15- to 30-min warm-up and cool-down period. Additionally, all Divisions completed 15–30 min of calisthenics (push-ups, sit-ups, crunches, lunges, etc.) $3\text{--}5$ d·wk⁻¹. During the seventh week of training, recruits participated in a second timed 1.5-mile run test. Recruits were required to complete the task with a maximal effort in order

to graduate from Boot Camp. Using the initial and final run times as measures of fitness and the mileage records from each division, the relationship between running/movement mileage and fitness improvement was examined.

Measures

Data collected included individual recruit initial and final run times for a 1.5-mile course, total recruit movement mileage by division, total recruit run mileage and run days by division, and recruit injury rates. The recruit running and movement mileage reflect the majority of the aerobic conditioning that the recruits experienced during training.

Initial and final training run times. Recruits performed a 1.5-mile run test during the first and seventh training weeks. The 1.5-mile run was completed on an indoor track, requiring nine laps. Recruits were instructed to run at their own pace and were allowed to walk during the test. Based on the results from the 1.5-mile run, recruits were assigned to one of six fitness categories (11). The timed run test was the primary measure of fitness used in this study, and the change in the run time was used to evaluate an individual's fitness improvement.

Recruit movement-miles, run-days, and run-miles. As part of training, recruit divisions marched in formation between activities on a daily basis. The marching tempo was typically equivalent to a brisk walk (3–4 mph). The distances covered by marching and incidental activity were termed movement mileage. Recruits wore boondockers, i.e., mid-calf boots, for these movements. Because recruit divisions were housed throughout the training complex, movement mileage accumulated by each division depended on the location of quarters even though all divisions conformed to similar training schedules. Each RDC maintained a daily log of every formation march by division, noting the point of origin and destination. Study staff checked these logs weekly for completeness.

Recruit Divisions ran throughout training as part of the physical conditioning program. Except for inclement weather conditions, the RDCs had sole discretion over the amount of running each division completed. In the log reports, the RDCs noted all run days and the total number of miles run each day. Recruits wore running shoes for all running sessions.

The daily logs were collected at the end of the training program. The total movement-miles, run-days, and run-miles were tabulated for each recruit division. These logs reflected the movement of a division as a unit and did not include individual mileage. Because recruits were monitored closely and had little free time during boot camp, individual variations in movement and running was negligible.

Recruit injuries. Recruit injuries were monitored throughout the training schedule using the Sports Medicine Research Team System (SMARTS) outpatient medical database in place at RTC, Great Lakes. In addition, the medical records of participating recruits were screened during the last week of training for lower limb musculoskeletal

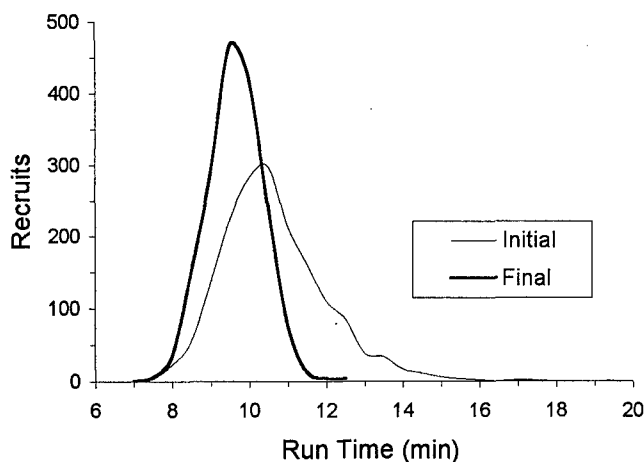


FIGURE 1—Distribution of initial and final 1.5-mile run times. Times recorded during the initial run (light line) and the final run (dark line) were plotted for the entire recruit population ($N = 1703$). The initial run times varied widely and resulted in a broad distribution curve. The narrow distribution of the final run scores shows that run times at the end of training were more uniform throughout the recruit population, and the majority of the recruits improved their run time.

injuries. If an injury was noted in the medical record, a copy of the physician or corpsman's note was entered into the database.

Statistical Analysis

The data were analyzed with the SAS statistical package (30). The division movement and running mileage variables were categorized into quartiles. The six baseline fitness levels, described by Cooper's age-adjusted scale (11), were collapsed into three levels ("Poor-Fair," "Good," and "Excellent-Superior") for analysis. Chi-square tests and analyses of variance tested for run time differences associated with division movement or run mileage as well as differences between baseline fitness levels. When these tests gave a significant result at the $P < 0.05$ level, Tukey's honestly significant difference test revealed which particular quartiles or scale levels differed. Injured and noninjured populations were compared using chi-square analyses. Relative risk and 95% confidence intervals were computed for results significant at the $P < 0.05$ level.

RESULTS

Data were collected from 1703 male recruits throughout the study period. The recruits completed the initial 1.5-mile run with an average time of $10:53 \pm 1:21$ min (7:49–19:48 min range). There were no overall age or fitness differences be-

tween the training divisions at the beginning of training. The final 1.5-mile run was given 6 wk later and was completed with an average time of $9:53 \pm 0:43$ min (7:14–12:34 min range). All recruits in this study completed the final run within Navy fitness readiness standards (9). In 1996 the minimum allowable 1.5-mile run time for 17- to 19-yr-old men was 12:45 min. Figure 1 shows the distribution of the recruit population for the two run tests. For the final run, the overall population improved its run time by $1:00 \pm 1:02$ min.

The 25 study divisions ran an average of 22.7 ± 7.2 miles (11.5–43.5 mile range) throughout training, including the distances covered during the steady-paced, maximal effort, 1.5-mile run tests. Three of these divisions ran fewer than 10 miles outside of the test situations. Additional physical activity performed each day was in the form of moving between barracks, classrooms, training areas, and dining facilities. The divisions covered an average of 145.1 ± 26.4 movement miles during boot camp with a range of 110–202 miles.

Table 1 gives a fitness classification of the recruit population at the beginning and end of recruit training. Upon initial entry to boot camp, approximately one third of the recruits were represented by each fitness category. Recruits who began training in the Poor-Fair group showed the greatest fitness improvement, with an average decrease in run time of $1:55 \pm 1:06$ min. The Good group improved by 47 ± 37 s, and the Excellent-Superior group improved by 17 ± 32 s. The run time improvement differed significantly between each of the initial fitness categories ($P < 0.01$). At graduation, more than 60% of the recruits were categorized in the Excellent-Superior group, whereas less than 5% were in the Poor-Fair category (Table 2).

Within a baseline fitness category, the improvement from the initial run to the final run was similar, regardless of the running or movement mileage covered (Fig. 2). Dividing the divisions into quartiles defined by movement mileage and run mileage yielded similar results (Table 3); regardless of the running or movement mileage covered during training, there were no differences across divisions in run time improvement.

There were 313 (18.4%) injury recruits with 334 musculoskeletal injuries (Table 3). Recruits assigned to the divisions having the highest quartile of running mileage had a significantly higher injury rate (22.4% vs 17.2%; $P < 0.02$). This was especially true when those recruits who entered boot camp with a Poor-Fair or Good initial run fitness rating in the highest quartile run division were compared with the lower three run mileage quartiles Poor-Fair or Good initial test recruits (24.2% vs 16.4% $P < 0.005$; relative risk 1.6, 95% confidence interval 1.2–2.2).

TABLE 1. Change in run time according to initial fitness classification.^a

Initial Fitness Level	N	Initial Run Time (min:s \pm SD)	Final Run Time (min:s \pm SD)	Improvement (min:s \pm SD)	Percent Improvement
Excellent-Superior	558 (32.8%)	9:42 \pm 0:40	9:25 \pm 0:39	0:17 \pm 0:32*	2.9%
Good	582 (34.2%)	10:42 \pm 0:38	9:55 \pm 0:33	0:47 \pm 0:37*	7.3%
Poor-Fair	563 (33.1%)	12:15 \pm 1:10	10:20 \pm 0:38	1:55 \pm 1:06*	15.7%

* Significant at $P < 0.01$ level.

^a Cooper's age-adjusted scale (11).

TABLE 2. Final fitness categories.^a

Final Fitness Category	N	Initial Fitness Category		
		Excellent-Superior	Good	Poor-Fair
Excellent-Superior	1030 (60.5%)	520	352	158
Good	601 (35.3%)	37	223	341
Poor-Fair*	72 (4.2%)	1	7	64

* Everyone in this category improved to at least 'Fair.'

^a Cooper's age-adjusted scale (11).

DISCUSSION

The aerobic fitness of male naval recruits was tested at the beginning and end of boot camp with a steady-paced, maximal effort, 1.5-mile timed run test. Burger and colleagues (8) verified this run test as an accurate measure of aerobic capacity because it reliably predicted $\dot{V}O_{2\max}$ in a young, male population. The most important predictor of fitness improvement was the baseline fitness level of the individuals. Recruits who were in poor physical condition at the beginning of boot camp improved their run times more than those who entered in better condition. This improvement was independent of the amount of run mileage accrued during the 8-wk boot camp program. We propose that the magnitude of the fitness improvement (i.e., faster final run time) demonstrated by the recruits was directly related to baseline fitness level affected by an accumulation of daily, moderate physical activity that

included movement mileage, run mileage, calisthenics, and task-specific training maneuvers.

In addition to running, the recruits participated in a balanced physical training regimen that included moderate cardiovascular activity, calisthenics, and proper stretching. The combination of aerobic exercise, muscle strength/endurance training, and flexibility workouts provided a well-rounded fitness program that trained all the major muscle groups of the body, resulting in general physical conditioning of the recruits (25). Because the calisthenics were performed in short bouts of 2–3 min and not in a circuit manner that would induce a major aerobic response, their direct role in run time improvement was probably minimal. However, these exercises toned muscles and prepared the body for use, contributing to the overall well-being and health of the recruits (23). These dose-response effects were more pronounced in the least-fit recruits, who had the most to gain by any increase in physical activity levels (15).

Most exercise research has studied the effects of single sessions of continuous aerobic activity (20–60 min) on fitness. However, recent studies have indicated that short bouts of activity, typically 10–15 min, throughout the day can be as effective as a single bout (2,12,13,15,20,27). The total daily energy expended due to accumulated exercise may be the critical factor in determining fitness improvement (12,14). Although organized exercise sessions were an essential part of the fitness program at boot camp, the recruits engaged in a lot of daily, intermittent exercise by marching from evolution to evolution, 3.5 miles a day on average. Military marching requires 6.5 times more metabolic energy expenditure than sitting quietly (6.5 METs vs 1 MET) (1). This habitual, but low-impact, physical activity provided the physiological stimuli needed to promote physical fitness in this population (4,15,24).

A greater risk of injury is associated with exercise programs that maintain excessive run mileage without a concomitant increase in the fitness benefit (5,16,19,26). The recruits in this study who accumulated the highest run mileage (>25 miles) also had the highest incidence of injury, whereas the improvement in their final run times did not differ from those recruits who ran half (or less) the number of miles. Overuse injuries and subsequent rehabilitation during boot camp cost the military millions of dollars each year in direct medical costs and lost training days (17). In addition, recruits who are injured during boot camp are less likely to complete their first term of enlistment than their uninjured counterparts (7). By reducing recruits' exposure to excessive run mileage (>25 miles), their risk of injury is dramatically diminished without negatively affecting physical readiness.

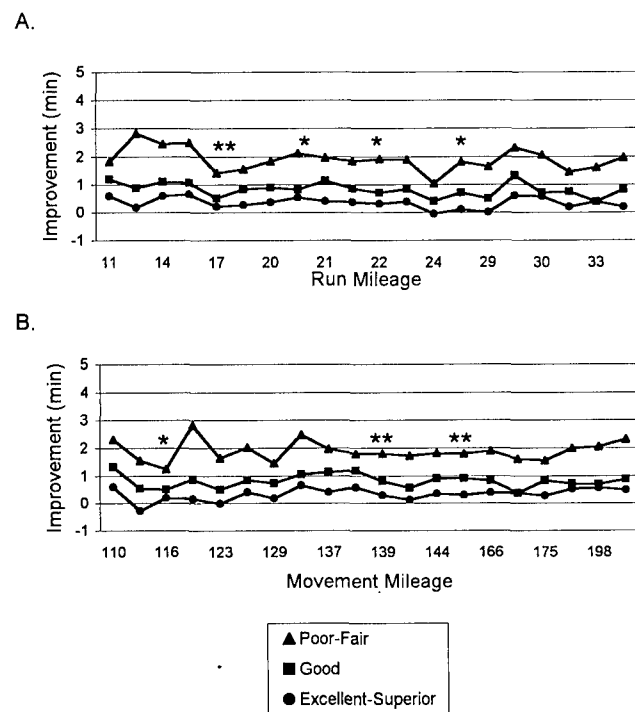


FIGURE 2—1.5-mile run time improvement by a Division's run/movement mileage and baseline fitness classification. The average improvement in run time (shown in minutes) for each division is plotted against run mileage (A) and movement mileage (B) covered during the training period. Data were stratified by baseline Cooper fitness level: "Excellent-Superior" (●), "Good" (■), "Poor-Fair" (▲). Divisions that had the same run or movement mileage were averaged together and plotted as a single point. * represents two Divisions; ** represents three Divisions.

TABLE 3. Comparison of recruit run times with movement and run mileage.

Mileage Covered	N	Initial Run (min:s \pm SD)	Final Run (min:s \pm SD)	Improvement (min:s \pm SD)	Injury (N)
Movement mileage					
Quartile 1: 110–124	442	10:58 \pm 1:24	9:58 \pm 0:45 ^{*2}	1:00 \pm 1:05	99
Quartile 2: 125–138	328	10:50 \pm 1:13	9:44 \pm 0:40 [*]	1:06 \pm 0:57	63
Quartile 3: 139–165	522	10:52 \pm 1:23	9:56 \pm 0:43 ^{*2}	0:56 \pm 1:05	71
Quartile 4: 166–202	411	10:51 \pm 1:22	9:51 \pm 0:41	1:00 \pm 1:01	80
Run mileage					
Quartile 1: 11.5–17.5	446	10:50 \pm 1:26	9:51 \pm 0:41 ^{*4}	1:00 \pm 1:09	73
Quartile 2: 18.0–21.5	407	10:53 \pm 1:18	9:48 \pm 0:45 ^{*4}	1:05 \pm 0:56	75
Quartile 3: 22.0–25.0	434	10:49 \pm 1:20	9:55 \pm 0:45	0:53 \pm 1:02	72
Quartile 4: 25.5–43.5	416	11:00 \pm 1:20	9:58 \pm 0:40 [*]	1:02 \pm 1:02	93

Recruit run times were quartiled according to movement/running mileage accumulated during training and averaged for comparison.

^{*2} Significant difference from movement quartile 2 value ($P < 0.05$).

^{*4} Significant difference from run quartile 4 value ($P < 0.05$).

The purpose of Navy boot camp is to teach recruits about the Navy and to train them to be good sailors. Part of the curriculum stresses physical fitness because naval personnel are required to satisfy biannual physical readiness standards, which are associated with job demands. One third of new recruits report to the RTC in poor physical condition after engaging in a sedentary lifestyle. After 8 wk of training, the majority of these recruits meet or surpass Navy fitness standards (9). These results have important implications for physical fitness programs in the armed forces as well as in the general population because recruits represent a subset of American adolescents and young adults. By teaching recruits to integrate moderate physical activity into their daily lives, they learn that health and fitness benefits can be achieved without engaging in strenuous and potentially dangerous activity (15). A broader range of acceptable behaviors (i.e., ability to improve cardiorespiratory fitness with

activities other than running) also promotes adherence to a physical activity program (23).

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Human subjects participated in this study giving their free and informed consent. This research has been conducted in compliance with all applicable Federal Regulations governing the Protection of Human Subjects in Research.

Address for correspondence: Tamara V. Trank, Ph.D., Naval Health Research Center, P.O. Box 85122, San Diego, CA 92186-5122; E-mail: trank@nhrc.navy.mil.

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13. ABSTRACT (Maximum 200 words) Purpose: The purpose of this study was to determine if varied amounts of running and movement mileage affect overall fitness improvement. Methods: Subjects were male U.S. Navy recruits (N = 1703, 25 divisions), ages 17-35 yr (mean age = 20.1 ± 2.9 yr), who attended boot camp from April 1996 through August 1996. During the first week of training, recruits performed a 1.5-mile run to determine baseline fitness levels. The results from the initial run were compared with a final 1.5-mile run conducted 7 wk later. Results: Based on an age-adjusted fitness scale for a 1.5-mile run time, about one third of the recruits began recruit training in "Excellent-Superior" condition (N = 558), one third began in "Good" condition (N = 582), and one third began in "Poor-Fair" condition (N = 563). Running mileage among divisions ranged from 11.5 to 43.5 miles for the entire 7 wk training period (mean = 22.7 ± 7.2 miles; 8-22 run days, mean = 13 ± 4 days). In addition to running, the divisions accumulated many movement miles (110-202 miles; mean = 145 ± 26 miles) while marching in formation. Recruits who began training in Poor-Fair condition improved the most with an average decrease in run time of 1:55 ± 1:06 min. The Good group improved by 47 ± 37 s, and the Excellent-Superior group improved by 17 ± 32 s. Conclusion: The magnitude of fitness improvement, as measured by run time improvement, was directly related to incoming fitness level but not related to movement mileage or high intensity run mileage accrued during training.					
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